Thursday, February 14, 2019

Potential Scope Items: Red Hill Bulk Fuel Farm

Key Purpose: Validate and further characterize and parameterize the CSM such that LNAPL and contaminant transport is better understood so that risk and risk management evaluations can be completed along with the uncertainties therein. Singularly and in combination, these data and evaluations can assist in developing a regulatory position on concurrence or otherwise with aspect of the Navy team's CSM that pertain to risk and risk management. Note that all items suggested can be accomplished without the installation of new investigatory borings/wells.

1. Observational groundwater flow evaluations. Goal: a site data driven understanding of groundwater flow and its variation with other hydrologic inputs and features to better the hydrogeologic CSM. Use this better understanding to set more appropriate flow calibration expectations of the Navy's groundwater model(s).

    a. Establish empirical understanding of gradients and likely flow directions given available synoptic head data and understanding of geologic anisotropy.
        i. With RH pumping
        ii. Without RH pumping
        iii. Different Halawa shaft pumping conditions
        i. Evaluate gradients when the Red Hill Shaft was down for repairs (period of concern February through November of 2016)
        iv. Responses to infiltration & other events
    b. Status: Matt & Bob have begun semi-independent evaluations. A combined and systematic suite of evaluations is pending.

2. Groundwater temperature mapping. Goal: to infer connectivity of groundwater flow between different aquifer zones and wells. Consider also the implications to biodegradation of fuel hydrocarbons.
    a. Synoptic temperature mapping and evaluations to understand the potential relationships between spatial and temporal variations and their implications to groundwater flow/connectivity.
    b. Review and consider the temperature gradients (vertical and lateral) and the implications with respect to ocean input, recharge, and discharge
    c. Consider the overprint of biodegradation-induced temperature changes in context with the above, as well as with the isotopic and groundwater chemistry evaluations below.
    d. Status: Don has done some early work arranging the USGS synoptic data sets, but no mapping or other evaluation work has been done.

Commented [D1]: Mapping program – how do we deal with temperature gradients? RHMW05; do we want to get better temperature gradients in these holes?

3.
4.
5. Groundwater isotope and general chemistry mapping and interpretation. Goal: another

related evaluation suite to understand the mechanics of the groundwater flow and transport system, as well as hydrocarbon degradation.

a. TEA and related evaluations over time (DO most available)
b. Isotopic trends and distribution
c. CoC mapping over time, potential correlations to vapor monitoring data
d. Status: Bob & Don have reviewed these data and we are awaiting an additional deliverable from the Navy. Matt has plotted synoptic DO, TPH and Naphthalene measurements from the Navy sampling records that show the expected DO depletion halo around the Red Hill tank farm, and general correspondence with PVOC detections. Bob has also plotted TPH and Naphthalene data at RHMW01 & 02 vs rainfall intensity (in/d) between sampling events.

Commented [WR2]: We don't have temporal trends, but have good O&H isotope spatial distribution, some N isotope data outside of Red Hill, and S isotope data currently only from Red Hill.

6. Combine (1) through (3) into a comprehensive empirical mapping and evaluation of likely groundwater flow patterns and PVOC migration patterns and characteristics. This provides a foundation for validating the groundwater transport model (and also the linkage with the source term from any LNAPL simulations).
   a. Develop estimates of region impacted by tank farm releases
   b. Status: sub-parts of the work are underway, the subparts need to be completed, and then combined (overlaid, boundaries delineated, etc.) to make the combined comprehensive evaluation.

7. Review the Navy's 3-D geologic model. Goal: to understand the geologic underpinning to their CSM and groundwater model construction. Compare and contrast with our own SME interpretations.
   a. Map dip vectors to evaluate fabric and variation from the tank farm outward
   b. Review scale-dependent features and their representation in the g.w. model
   c. Evaluate the saprolite contact and related interpretations of this potential flow barrier relative to the g.w. flow and transport patterns observed
   d. Status: Features of the geologic CSM are being reviewed in the GWD environment as they are provided. A call was held between Bob, Don and Matt to review the volcanics/tuffs; the saprolite was briefly reviewed however new data regarding saprolite-bedrock interface depth suggest these surfaces may need further revision. These new data need to be reviewed in the context of the surfaces provided by the Navy. The cap rock representation also is in the GWD environment but needs to be reviewed by the regulator SMEs collaboratively.

8. Review and evaluation of LNAPL releases in volcanic settings. Goal: to better understand the transport behavior of LNAPLs following its release and the associated impacts caused to groundwater.
   a. Aloha Petroleum - Hilo; GD in process, fairly detailed evaluation completed, however key questions remain unanswered by available sources.
   b. Wheeler AFB - Oahu. Bob has compiled some of the data sets. There are instructive observations of g.w. impacts and persistence. However, the release character differs substantially from that expected at Red Hill due to comparatively

Commented [D3]: Need to get better definition of release rates from the tanks…
GD – we need, at some point, a direct interaction with Phil Meyers to understand release mechanisms, magnitudes, etc.

large saprolite thickness and absence of release characteristics.

c. Other Hawaii-specific LNAPL release cases within the hard-rock volcanic domain. GD has made inquiries, but no tangible case responses to date. We suspect that there are likely releases at most airports/bases with large volumes and history of fuel handling based on parallels to mainland sites where releases are prevalent.
d. Others - Pacific NW, other volcanic islands with refineries?
e. Status: GD has made limited inquiries, but responses have been limited, although there are clearly cases that may be instructive. This item is pending until we try again to find Hawaii specific cases.

9. Run the Navy base model with new anisotropy and boundary assumptions. Goal: to try to better represent this groundwater flow/transport system and to test assumptions that the Navy has not. Matt has made some model adjustments and found that there is potential groundwater flow toward Halawa shaft under a differing anisotropy within the range of field measurements and pumping conditions.
    a. Test combined conditions to better represent magnitude & direction of flow
    b. See if new conditions better explain observations above
        i. Gradients along Red Hill ridge(?)
        ii. Distal transport implications
        iii. Deep v shallow connectivity
    c. Other scenarios - transient boundaries? Transient assessment of capture in the short-term (days) to be consistent with the potential rate of LNAPL transport resulting from a substantial release.
    d. Status: these simulations are on hold pending receipt of the revised model grid and structure, orientation; which in turn is pending regulator approval of the volcanics (seem broadly ok), saprolite-bedrock interface, and cap rock.

Commented [D4]: I would prefer "toward" rather than to – the latter presumes that contaminants have been detected there…

10. Organize and extend LNAPL screening modeling. Goal: to understand the sensitivity and uncertainty regarding potential transient outcomes of various LNAPL release scenarios. The work of the model setup is complete, so such quantitative investigations can be efficient.
    a. Release scenarios and application throughout the tank farm (Phil Meyers input)
    b. Geologic distributions via kriging of barrel logs.
    c. Estimated parameter ranges and discussion
    d. Literature/experience based parameters
    e. Discussion of model assumptions & limitations
    f. Matrix of modeling runs
    g. Matrix and animation of results
    h. Sensitivity summary
    i. Status: No substantial work has been completed since August 2018.

11. Detailed review of Navy CSM & Protection reports. Goal: we anticipate the Navy's

work to continue along the lines presented in these reports. There was insufficient review time when these were produced to the regulatory team, and no comprehensive review or technical positions have been completed to date.

a. Section by section analysis, with each assigned to a point person with support from the other SMEs
b. Regulatory positions (internal use & planning only); determine the stances on concurrence or deficiencies that the regulatory team will potentially adopt as a result of these detailed reviews.
c. Determination of whether or not the Navy team's approach is conservative, as they have consistently indicated in meetings and work products
d. Status: Only limited focused review was completed on the drafts in July/August, due to schedule and emphasis on the groundwater model. No further action since that time.

Commented [WR5]: I think an efficient way to accomplish this is to review their lines of evidence, then work backward to see how well each LOE is supported.
GD – agreed, there is a lot of information in the chemistry discussion that, in general, argue for the minimization of data acceptance. I'd think we'd parse this down by looking at TOC section of interest and perhaps there are some where we find agreement, and some of non-concurrence

12. Data Collection: Conduct vapor tracer testing with UH assistance and possibly other contractors (e.g., TracerTight or others). This is a relatively common technical approach to characterizing flow through porous and fractured media and has the advantages of being inexpensive and of short duration in the field application. Goals: First, to test/validate whether there are ongoing chronic releases from the Red Hill Tanks. Second, to evaluate flow and transport conditions in the vadose zone that will be a key control over LNAPL transport following releases.
    a. Tanks 6 and 18 would be the candidates due to periodic high TVH readings in the vapor probes beneath those tanks. The tests would add SF6 or other tracer into the fuel tanks via observation ports or other topside locations. Monitoring for the potential tracer escape from the tanks would use the existing SV probes.
    b. Conduct forced flow vapor tracer testing using RHMW01, -02, and -03 as the extraction points. Inject tracers into various vapor probes beneath the tanks, starting with the Tank 5 series of probes. Injection into each probe would use a different vapor tracer to allow separation of the flow and recovery response. Tank 6 would follow the Tank 5 tracer testing. The testing would then progress up-ridge to the area of RHMW03 (Tanks 13 - 16), and then down-ridge to the area of RHMW01 (Tanks 1 & 2). The distance between RHMW01 and these tanks is more than 200-ft, which may limit the effectiveness of the tracer testing, although if flow conditions are partly confined, the distance may be acceptable.
    c. This testing will provide direct measurements of the air permeability, flow rates, the variation of such, fracture/void continuity, etc.

Commented [D6]: How do we do that? Do we need to do work to see how volatilization proceeds from these fuels and how the volatile composition changes with time? This also relates to GSI's contention that we are seeing "old" fuel – do we want to understand the aging process better so that we can distinguish between a current leak and older releases. Do we see "fractional" volatilization of a new release: lightest hydrocarbons first followed by less volatile and metabolites later?
GD – this is a specific tightness test method using tracer. It's put into the fuel system, and if one detects the tracer at the probes, it means there is a leak in the system.

Commented [D7]: I think that this would be the more appropriate goal of a volatile tracer test in which SF6 or some such would be injected. Only after transport properties are defined (to some limited degree) would we be able to clearly interpret volatile monitoring data to determine ongoing releases…
GD – see above, 1st step it tank tightness, 2nd is tracerr transport

Commented [D8]: I would be inclined to make this a second stage to the testing: injection of SF6 at known points and detection at others will tell us vapor flow trajectories; injection of SF6 into the tank gives us detections from an unknown injection point – we should discuss in detail….

Commented [D9]: Again, not knowing likely transport pathways would make success of this somewhat problematic…
GD – see item C. The transport tracer would be to observe & evaluate flow paths, travel times, and other variations to map out, to some degree, the nature and heterogeneity of the system.

13. Data Collection. Conduct groundwater tracer testing. Goal: to directly measure flow paths and rates of tracer migration and compare those to the g.w. modeling predictions and underlying CSM.
    a. Pretest planning (1). Develop a list of questions we expect the tracer test to answer, then use the prioritizing of these questions to guide the tracer test design.
    b. Pretest planning (2). Run g.w. transport simulations of tracer additions into

RHMW02 to determine the injection concentrations, duration, etc. for the predicted tracer arrival at various wells in the monitoring array. Given the relatively large distances between monitoring wells, it is anticipated that tracer arrival may take weeks to months for arrival to be detected. Automated detectors are therefore suggested for this type of test.

c. It is expected that there will be varied groundwater production in the aquifer based on the service needs of the Navy and BWS. While not ideal, it is unlikely that we will be able to control those pumping regimes. Instead, those will need to be recognized and accounted in the evaluations of the data responses.

14. Data Collection: Conduct vertical flow and groundwater quality profiling at RHMW01 – RHW05. Goal: to better understand variance in discrete flow as it relates to heterogeneity and connectivity between wells and within the geologic system. With respect to contaminant migration, the chemical profiling may also suggest if an LNAPL residual source is in contact with groundwater and potential where within the vertical profile.

    a. Remove existing pump and sampling equipment from these wells and allow an requilibration time of two weeks at ambient conditions.

    b. Perform the vertical flow profiling at 1-ft increments. The measurement method will be determined based on discrete flow range estimates from the Navy team's numerical groundwater model. There are four common measurement methods: i) colloidoscope; ii) heat-pulse; iii) electromagnetic; and iv) spinner wheel. Of these, the colloidoscope is the most flexible and provides excellent range, but is also the most work intensive. The others have flow and sensitivity limitations, but are perfectly sufficient if flow is within those limits.

    c. Perform vertical contaminant and groundwater quality profiling at one-foot increments. This would include the basic petroleum analytes run in the Navy's groundwater sampling program, temperature, dissolved-oxygen, and biodegradation parameters. There are three general sampling methods to vertically profile groundwater quality: i) diffusion bags, an integrated sample; ii) low-flow pumping

15. Data Collection: Conduct detailed geologic mapping and evaluations at the Quarry and/or other geologic exposures of a comparable elevation and setting to those beneath the Red Hill tanks and couple these with the barrel logs of the Red Hill Tank construction. Goal: to better understand the hydrogeologic architecture that will control contaminant movement and in particular, the transport of LNAPL through the vadose zone and to the aquifer. These tasks are envisioned to be undertaken by UH students under the direction of Don Thomas, Scott Rowland and with support from the SME team.

    a. Measure the range and variability of strikes and dips, determine true dip azimuths through planar and slope trigonometry.

b. Determine fracture, void and clinker characteristics as they relate to the bedding characteristics above. Where possible, measure and characterize the void features, such as spatial density, void apertures, continuity, wall character, mineral in-filling, etc.

c. Status: discussions held between regulator SMEs and representatives of UH, and some `collaborative work between Bob and Navy team, but no specific actions since that time. Currently working on a SOW for Scott Rowland.

16. Develop meso-scale LNAPL transport parameters from literature information, field and bench testing. Goal: to begin to understand the critical parameter ranges and variability that will directly control LNAPL migration and ultimately the potential risks posed.

    a. Perform LNAPL infiltration tests in an analogous manner as standard unsaturated zone infiltration testing (e.g., Guelph permeameter, double-ring infiltrometer, etc.). This would be done at suitable hard-rock volcanic setting locations using a benign LNAPL (e.g., vegetable oil cut with ethanol).

    b. Evaluate the residual saturation capacity of different volcanic materials. This could be accomplished by collecting samples of key lithologic units from the quarry or other locations and then bulk-testing those in diesel-fuel baths and accounting for the mass uptake on the material faces/pores and then correcting for other factors of test-to-field scaling.

    c. Test the same types of volcanic materials for wettability. This can be done using the sessile drop method that is essentially an observation of the water or LNAPL behavior when a drop of the liquid is placed on a rock interface. The method will be less effective in saprolites or other porous materials where the Amott-Harvey method would be more suitable.

17. Develop a unified understanding of the current monitoring data sets for dissolved hydrocarbons.

    a. Evaluate existing/archival data sets to determine what GC traces for samples that are free of hydrocarbon contaminants and metabolite compounds looks like and define, if possible, a baseline "clean" groundwater

    b. Determine whether there is an age relationship present in the hydrocarbon GC traces for metabolite compounds – either in the field data or in laboratory samples

    c. "Map" TPH/metabolite integrals to determine the extent of the apparent (metabolite) plume

    d. Evaluate metabolite integrals and DO and other TEA data to determine whether there is a correlation among those different, but complementary data

    e. Determine whether there are other (more definitive) methods of identifying hydrocarbon/metabolite concentrations (e.g. fluorescence mapping).

Misc notes from Don T.:

Where are we on alkalinity data where alkalinity may be derived from microbial respiration?

Do we want to get a fix on the age of the water – either as a proxy for fuel breakdown or to get a handle on the rates of transport into and through the system – e.g. HDMW?

And if we want to get into lunatic ideas for tracers/proxies for hydrocarbon transport:

we could do DNA on the microbial communities – although it might take years to understand what we are seeing…

With respect to HDMW and AECOM's contention that it is responsible for the elevated chlorides in the Makai wells, do we want to inject a tracer there, in the upflow zone to confirm or refute that?

Another off the wall idea: Is there any point in discussing injection of a tracer into RHMW06 and looking for it in HDMW? If we have flow toward the NW it is possible that we could see something…